GMR
The Original

CONE-BEAM COMPUTED TOMOGRAPHY-BASED MORPHOMETRIC ANALYSIS OF THE MANDIBULAR LINGULA AND ITS CLINICAL SIGNIFICANCE: A RETROSPECTIVE STUDY

Dr. Naveenkumar Shetty[1*], Dr. Mandavi S. Waghmare[2], Dr. Nisha Bharos[3], Dr. Kapil Gavand[4], Dr. Chintan Shah[5], Harsh Sanglikar[6]

[1*]Professor, Department of Oral Medicine and Radiology, D. Y. Patil University School of Dentistry, Navi Mumbai, Maharashtra, India, Email id: nksrad@rediffmail.com, Orcid id: 0009000509328648
[2]Professor and HOD, Department of Oral Medicine and Radiology, D. Y. Patil University School of Dentistry, Navi Mumbai, Maharashtra, India, Email id: mandavi.waghmare@dypatil.edu, Orcid id: 0000000189191218
[3]Student, Department of Oral Medicine and Radiology, D. Y. Patil University School of Dentistry, Navi Mumbai, Maharashtra, India, Orchid id: 0009000439365637
[4]Associate professor, Email id: kapil.gavand@dypatil.edu, Orchid Id: 0009-0007-2235-0625
[5]Lecturer, Department of Oral Medicine and Radiology, D. Y. Patil University School of Dentistry, Navi Mumbai, Maharashtra, India, Email id: drchintanshah09@gmail.com, Orcid id:0009000968419880
[6]Intern, D. Y. Patil University School of Dentistry, Navi Mumbai, Maharashtra, India, Email id: harshsan@icloud.com, Orcid id:0009000402992581

ABSTRACT

Background: The mandibular lingula is a key bony landmark for inferior alveolar nerve block (IANB) and mandibular ramus osteotomies, yet population-specific morphometric data for Indian patients derived from cone-beam computed tomography (CBCT) remain limited.

Aim: To determine the morphometric position of the mandibular lingula on CBCT and its correlation with age and gender in a Mumbai-based population.

Materials and Methods: This retrospective cross-sectional study analysed 42 full-skull CBCT scans (84 rami; 21 males, 21 females; age 18–65 years) from the archives of the Department of Oral and Maxillofacial Radiology. Five linear parameters—sigmoid notch-to-lingula (SNL), inferior ramus border-to-lingula (IBRL), anterior ramus border-to-lingula (ARL), posterior ramus border-to-lingula (PRL), and lingula length (LL)—were measured bilaterally using multiplanar reconstruction. Bilateral symmetry, gender comparison, and age correlation were assessed using independent t-tests and Pearson correlation (SPSS; $p<0.05$ significant).

Results: Mean SNL, IBRL, ARL, PRL, and LL were 17.41–17.82, 29.33–30.01, 13.32–13.71, 13.88–14.22, and 8.55–9.10 mm respectively. No significant right–left differences were found in either sex ($p>0.05$). Males showed significantly greater IBRL bilaterally (right: 32.60 vs 27.43 mm, $p=0.001$; left: 31.73 vs 26.94 mm, $p=0.001$), and greater left-sided ARL, PRL, and LL ($p<0.05$). No parameter correlated significantly with age (all $p>0.05$).

Conclusion: The mandibular lingula demonstrates bilateral symmetry, significant sexual dimorphism (particularly for IBRL), and dimensional stability across adulthood. These CBCT-derived normative values can guide safer, sex-specific IANB administration and osteotomy planning in this population.

KEYWORDS: Mandibular lingula; cone-beam computed tomography; morphometry; inferior alveolar nerve block; sagittal split ramus osteotomy; sexual dimorphism.

INTRODUCTION

The mandibular lingula is a slender, tongue-shaped bony projection on the medial surface of the mandibular ramus, first described by Spix in 1815.[1] On the basis of shape, Tuli et al. classified it into triangular, truncated, nodular, and assimilated types.[2] Developmentally associated with Meckel's cartilage, the lingula forms the anterosuperior boundary of the mandibular foramen, where the inferior alveolar neurovascular bundle enters the mandibular canal, and also serves as an attachment site for the sphenomandibular ligament.[3]

Clinically, During inferior alveolar nerve block (IANB), identification of the lingula assists in estimating the position of the mandibular foramen; inaccurate localisation may contribute to failed anaesthesia and complications including facial nerve palsy, trismus, and haematoma.[3,6]

The lingula is equally critical in orthognathic surgery. In sagittal split ramus osteotomy (SSRO), positioning the medial osteotomy cut posterosuperior to the lingula is recommended to minimise the risk of injury to the inferior alveolar nerve4; similarly, the intraoral vertico-sagittal (IVSRO) and intraoral vertical ramus osteotomy (IVRO) techniques require accurate lingula localisation to prevent nerve injury while ensuring adequate segment mobilisation.[4]

Variation in lingula position according to population and sex, with a possible influence of age, indicates that anatomical reference values from one population should not be directly generalised to another.[6,7] The high spatial resolution and relatively low radiation exposure of CBCT make it particularly suitable for three-dimensional lingular morphometry and allow assessment in vivo, unlike studies based exclusively on dry mandibles.[5,6] Indian population-specific CBCT data on lingula morphometry, however, remain sparse. This study was therefore undertaken to determine the morphometric

location of the mandibular lingula using CBCT, and to evaluate its correlation with age and gender in a western Indian (Mumbai) population.

MATERIALS AND METHODS

This retrospective cross-sectional study was conducted in the Department of Oral and Maxillofacial Radiology, D. Y. Patil University School of Dentistry, Nerul, Navi Mumbai, after institutional ethical clearance (Ref. IREB/2025/OMR/06). Sample size was calculated using the formula $n = (Z\alpha/2 + Z\beta)^2 \times (\sigma^{12} + \sigma^{22}) / (\mu_1 - \mu_2)^2$, yielding a minimum of 42 patients (84 rami). Accordingly, 42 full-skull CBCT scans (21 males, 21 females) taken between 1 June 2024 and 1 June 2025 were retrieved from departmental archives.

Inclusion criteria were age ≥18 years, good diagnostic-quality CBCT volumes free of artefacts, and an intact dentition or stable occlusal plane. Scans with inadequate field of view, prior orthognathic surgery, major jaw deformities, large cysts/tumours of the mandible, or a history of orthodontic treatment were excluded.

CBCT images were acquired on a Kodak Carestream 9600 unit (voxel size 0.3 mm; scan time 24 s; tube current 5 mA; tube voltage 120 kV; slice thickness 0.3 mm) and analysed on Carestream CS 3D Imaging software using multiplanar reconstruction (MPR) to standardise mandibular orientation.

CBCT-derived measurements

Five linear parameters were recorded bilaterally, in millimetres, for each ramus (Fig. 1–5):

- SNL – vertical distance from the deepest point of the sigmoid notch to the tip of the lingula (coronal slice).
- IBRL – vertical distance from the inferior border of the ramus to the tip of the lingula (coronal slice).
- ARL – horizontal distance from the anterior border of the ramus to the tip of the lingula (axial slice).
- PRL – horizontal distance from the posterior border of the ramus to the tip of the lingula (axial slice).
- LL – length of the lingula, from its base at the mandibular foramen to its tip (coronal slice).

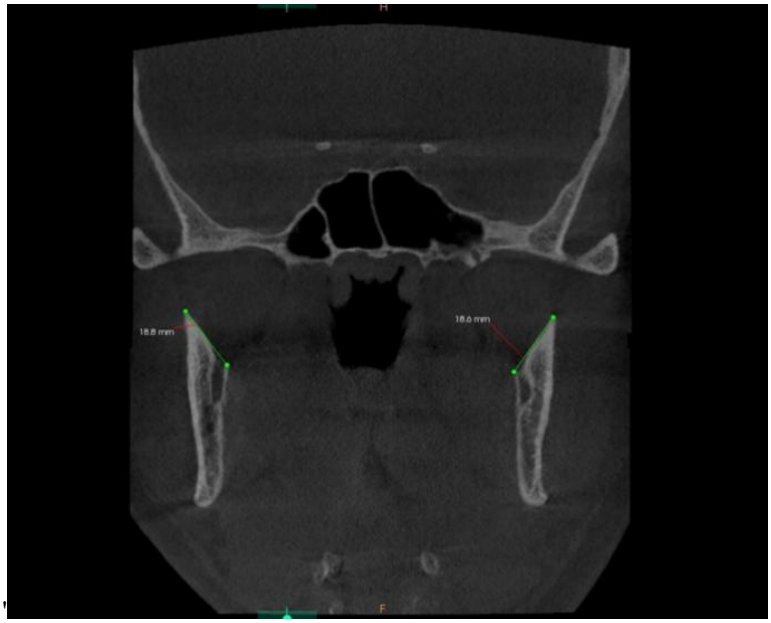


Fig. 1: Measurement of the superior distance (SNL) on a standardised coronal CBCT slice

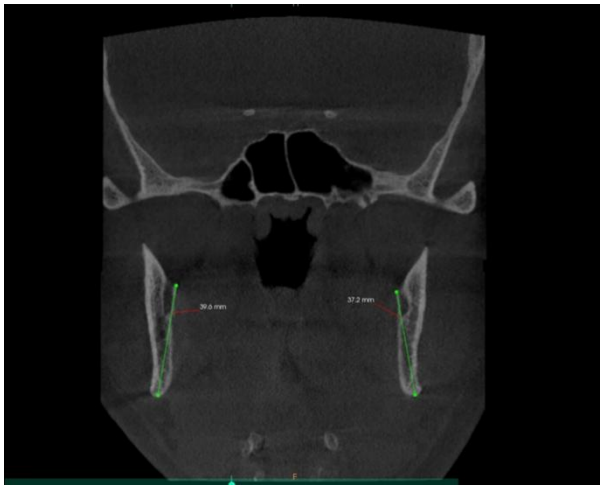


Fig. 2: Measurement of the inferior distance (IBRL) on a standardised coronal CBCT slice

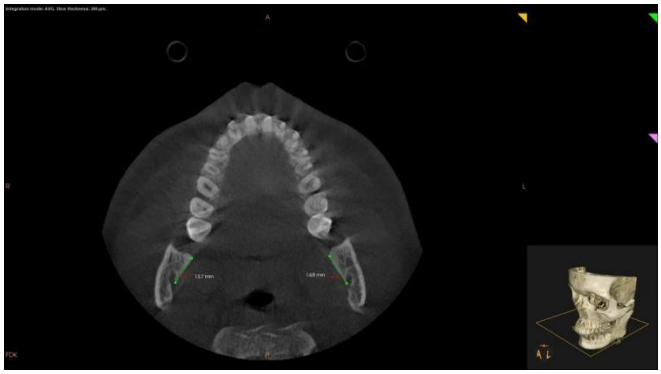


Fig. 3: Measurement of the anterior distance (ARL) on a standardised axial CBCT slice

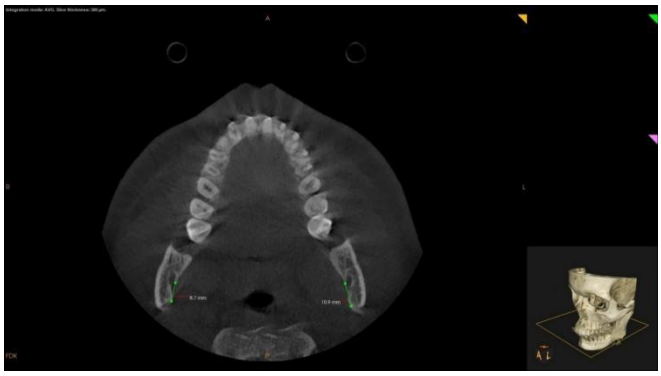


Fig. 4: Measurement of the posterior distance (PRL) on a standardised axial CBCT slice

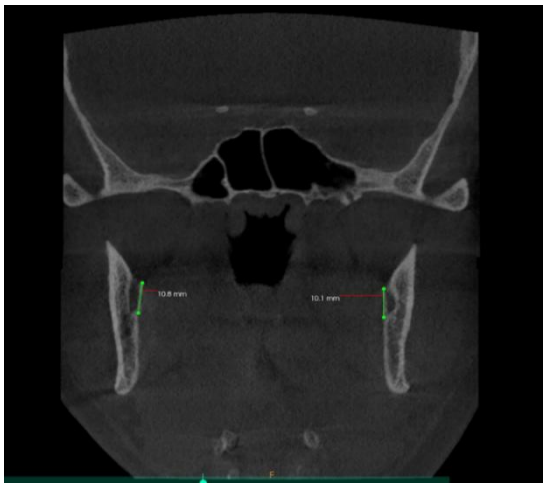


Fig. 5: Measurement of the length of the lingula (LL) on a standardised coronal CBCT slice

Statistical analysis

Data were analysed using SPSS (IBM Corp., Armonk, NY). Descriptive statistics (mean, standard deviation, range) were computed for each parameter. Right–left symmetry and gender differences were tested with independent-samples t-tests (Shapiro-Wilk confirmed normal distribution), and the age relationship with each parameter was tested using Pearson correlation. $p<0.05$ was considered statistically significant.

RESULTS

Forty-two patients (84 rami; 21 males, 21 females; age range 18–65 years) were evaluated.

Descriptive statistics

Mean, standard deviation, and range for all five parameters on the right and left sides are shown in Table 1. Right-sided means were: SNL 17.41 ± 3.43 mm, IBRL 30.01 ± 5.46 mm, ARL 13.71 ± 2.60 mm, PRL 13.88 ± 2.18 mm, and LL 9.10 ± 2.10 mm. Corresponding left-sided means were closely comparable (SNL 17.82 ± 3.88 mm, IBRL 29.33 ± 4.84 mm, ARL 13.32 ± 3.02 mm, PRL 14.22 ± 2.18 mm, LL 8.55 ± 1.74 mm), indicating overall bilateral symmetry.

Table 1: Descriptive statistics of mandibular lingula parameters (right and left sides)

Side	Variable	Mean (mm)	SD	Minimum	Maximum
Right	SNL	17.41	3.43	8.5	28.7
	IBRL	30.01	5.46	13.3	42.0
	ARL	13.71	2.60	8.7	19.4
	PRL	13.88	2.18	10.2	17.9
	LL	9.10	2.10	4.7	14.9
Left	SNL	17.82	3.88	12.5	32.9
	IBRL	29.33	4.84	15.3	39.1
	ARL	13.32	3.02	1.8	19.0
	PRL	14.22	2.18	10.0	19.6
	LL	8.55	1.74	4.6	12.5

Bilateral symmetry

Independent t-tests within each sex showed no statistically significant right–left differences for any parameter (all $p>0.05$) in males (Table 2) or females (Table 3), confirming bilateral symmetry of the lingula in both sexes.

Table 2: Comparison of right and left side measurements in male subjects

Variable	Right		Left		Difference	t-value	p-value
	Mean	SD	Mean	SD			
SNL	18.16	3.72	17.84	3.85	0.32	0.271	0.787
IBRL	32.60	4.71	31.73	4.02	0.87	0.645	0.523
ARL	14.20	2.06	14.36	2.54	-0.16	-0.227	0.822
PRL	14.49	2.11	14.91	2.15	-0.42	-0.638	0.527
LL	9.56	2.06	9.12	1.60	0.44	0.770	0.446

Table 3: Comparison of right and left side measurements in female subjects

Variable	Right		Left		Difference	t-value	p-value
	Mean	SD	Mean	SD			
SNL	16.67	3.03	17.81	4.00	-1.13	-1.035	0.307
IBRL	27.43	4.99	26.94	4.45	0.49	0.336	0.738
ARL	13.21	3.01	12.27	3.16	0.94	0.990	0.328
PRL	13.27	2.11	13.53	2.03	-0.26	-0.402	0.690
LL	8.63	2.07	7.97	1.72	0.66	1.135	0.263

Gender-based comparison

On the right side, males showed higher mean values than females for all parameters, reaching significance only for IBRL (32.60 ± 4.71 vs 27.43 ± 4.99 mm, $p=0.001$) (Table 4). On the left side, males had significantly larger IBRL (31.73 vs 26.94 mm, $p=0.001$), ARL (14.36 vs 12.27 mm, $p=0.023$), PRL (14.91 vs 13.53 mm, $p=0.039$), and LL (9.12 vs 7.97 mm, $p=0.029$); SNL was near-identical between sexes ($p=0.977$) (Table 5).

Table 4: Comparison of measurements between males and females – right side

Variable	Male		Female		Difference	t-value	p-value
	Mean	SD	Mean	SD			
SNL	18.16	3.72	16.67	3.03	1.49	1.420	0.163

IBRL	32.60	4.71	27.43	4.99	5.17	3.452	0.001*
ARL	14.20	2.06	13.21	3.01	0.99	1.238	0.223
PRL	14.49	2.11	13.27	2.11	1.22	1.870	0.069
LL	9.56	2.06	8.63	2.07	0.93	1.455	0.154

Table 5: Comparison of measurements between males and females – left side

Variable	**Male**		**Female**		**Difference**	**t-value**	**p-value**
	Mean	**SD**	**Mean**	**SD**			
SNL	17.84	3.85	17.81	4.00	0.03	0.029	0.977
IBRL	31.73	4.02	26.94	4.45	4.79	3.663	0.001*
ARL	14.36	2.54	12.27	3.16	2.09	2.363	0.023*
PRL	14.91	2.15	13.53	2.03	1.38	2.139	0.039*
LL	9.12	1.60	7.97	1.72	1.15	2.261	0.029*

Correlation with age

Age demonstrated only weak and non-significant relationships with each of the five lingular measurements on both sides, indicating minimal dimensional variation across the studied adult age range ($r = -0.211$ to 0.155; all $p>0.05$) (Table 6), indicating that lingula dimensions remain stable across the adult age range studied.

Table 6: Correlation between age and mandibular lingula parameters

Side	**Variable**	**r-value**	**p-value**
Right	SNL	-0.115	0.469
	IBRL	-0.211	0.179
	ARL	-0.016	0.920
	PRL	0.155	0.328
	LL	-0.027	0.866
Left	SNL	0.015	0.927
	IBRL	-0.049	0.760
	ARL	-0.188	0.233
	PRL	0.112	0.481
	LL	-0.075	0.638

DISCUSSION

This CBCT analysis establishes reference measurements for the mandibular lingula in a western Indian cohort and identifies three major patterns: comparable measurements between sides, sex-related dimensional differences, and absence of significant age-related variation during adulthood.

Measurements of all five parameters showed no significant side-to-side differences in either sex, in agreement with observations reported by Özalp et al., Ahn et al., and Tay and Ngeow.[1,6,5] The observed symmetry may permit measurements from one side to serve as a useful reference during bilateral procedures such as SSRO; nevertheless, individual anatomical variation should be considered during treatment planning.

Sex-related differences represented the most prominent observation, as males generally demonstrated greater lingular dimensions, with the largest difference involving IBRL, which was approximately 5 mm greater on both sides ($p=0.001$); significant differences were also observed for left-sided ARL, PRL, and LL. Similar sex-based differences have been reported by Jang and Han, Zhou et al., Tekin et al., and Tay and Ngeow.[7,5] The observed sexual dimorphism may be related to differences in mandibular growth and overall ramus dimensions between males and females, with potential implications for clinical localisation of the mandibular foramen.

No significant correlation was observed between age and any lingula parameter ($r = -0.211$ to 0.155, $p>0.05$ for all), consistent with the concept that mandibular dimensions stabilise once skeletal maturity is reached. This contrasts with paediatric literature documenting age-related change and reinforces that adult normative values need not be age-adjusted within the 18–65-year range studied.

Comparison with earlier Indian dry-mandible studies revealed notable differences; for example, Padmavathi et al. reported ARL and PRL values of 21.32 mm and 19.61 mm respectively4, considerably higher than the combined means of 13.5 mm and 14.1 mm observed here. The variation between these measurements may be attributable to differences in measurement protocols, the use of dry skeletal specimens, and anatomical diversity among Indian populations. In contrast, our findings showed greater similarity to values reported in international CBCT studies, including those of Tekin et al. and Tay and Ngeow, the latter confirming that Indians tend to have smaller rami with more antero-inferiorly placed lingulae than other ethnic groups.[5]

These findings offer practical guidance: the ARL and PRL values place the lingula close to the ramal midpoint, supporting conventional IANB teaching, while the observed variability (SD 2.2–5.5 mm) underscores the value of preoperative CBCT for individualised planning in SSRO and IVRO. The documented sexual dimorphism may additionally have forensic application in sex estimation from fragmentary mandibles.[3]

Interpretation of these findings should consider the single-centre design and relatively small cohort of 42 participants, which may limit their representativeness of the broader Indian population. Morphological classification of lingula shape was not performed, edentulous patients were excluded, and soft-tissue relationships relevant to IANB were not assessed. Patients with prior orthodontic treatment were also excluded, which may have removed cases of treatment-related positional change. Larger, multicentric studies incorporating morphological typing and soft-tissue assessment are recommended.

CONCLUSION

This CBCT-based morphometric analysis provides normative data on the mandibular lingula for a Mumbai-based population and confirms bilateral symmetry, significant sexual dimorphism (most marked for IBRL, approximately 5 mm greater in males), and stability of lingula dimensions across adulthood, with no significant age effect. These findings support sex-specific, evidence-based planning for inferior alveolar nerve block administration and mandibular ramus osteotomies, and add to the growing body of population-specific normative data relevant to surgical anatomy and forensic identification. Larger multicentric studies are warranted to validate and extend these findings.

Conflicts of interest: Nil.
Source of funding: Nil.
Ethical clearance: Institutional Research Ethics Board, Ref. IREB/2025/OMR/06.

REFERENCE

1. Özalp Ö, Salim H, Bilgin B, Öztürk S, Doğan MS, Göztepe MB, et al. Morphologic and morphometric analysis of mandibular lingula. Anatomy. 2020;14(1):16-21.
2. Tuli A, Choudhry R, Choudhry S, Raheja S, Agarwal S. Variation in shape of the lingula in the adult human mandible. J Anat. 2000;197(2):313-7.
3. Sophia MM, Alagesan A, Ramchandran K. A morphological study of mandibular lingula and its clinical significance. Int J Med Res Rev. 2015;3(2):141-8.
4. Padmavathi G, Varalakshmi KL, Tiwari S, Roopashree K. A morphological and morphometric study of the lingula in dry adult human mandibles of South Indian origin and its clinical significance. Int J Health Sci Res. 2014;4(6):56-61.
5. Tay HW, Ngeow WC. A cone-beam computed tomography study of the morphological and morphometric variations in the mandibular lingula and its clinical implications. Diagnostics (Basel). 2025;15(16):2071.
6. Ahn BS, Oh SH, Heo CK, Kim GT, Choi YS, Hwang EH. Cone-beam computed tomography of mandibular foramen and lingula for mandibular anesthesia. Imaging Sci Dent. 2020;50(2):125-32.
7. Jang HY, Han SJ. Measurement of mandibular lingula location using cone-beam computed tomography and internal oblique ridge-guided inferior alveolar nerve block. J Korean Assoc Oral Maxillofac Surg. 2019;45(3):158-66.
8. Kim HJ, Lee HY, Chung IH, Cha IH, Yi CK. Mandibular anatomy related to sagittal split ramus osteotomy in Koreans. Yonsei Med J. 1997;38(1):19-25.
9. Kositbowornchai S, Siritapetawee M, Damrongrungruang T, Khongkankong W, Chatrchaiwiwatana S, Khamanarong K, et al. Shape of the lingula and its localization by panoramic radiograph versus dry mandibular measurement. Surg Radiol Anat. 2007;29(8):689-94.
10. Sekerci AE, Sisman Y. Cone-beam computed tomography analysis of the shape, height, and location of the mandibular lingula. Surg Radiol Anat. 2014;36(2):155-62.
11. Tekin G, Kose NS, Ugurlu M, Dereci O, Kosar YC, Gojayeva G, et al. Determining the safety margin of mandibular lingula in sagittal split ramus osteotomy. Surg Radiol Anat. 2024;46(2):159-66.
12. Zhou C, Jeon TH, Jun SH, Kwon JJ. Evaluation of mandibular lingula and foramen location using 3-dimensional mandible models reconstructed by cone-beam computed tomography. Maxillofac Plast Reconstr Surg. 2017;39(1):30.
13. Choi DY, Hur MS. Anatomical review of the mandibular lingula for inferior alveolar nerve block. Anat Cell Biol. 2021;54(3):293-300.